EXAMPLES OF EARTH PRESSURE COMPUTATIONS USING THE SIMPLIFIED PRESSURE COEFFICIENT METHOD

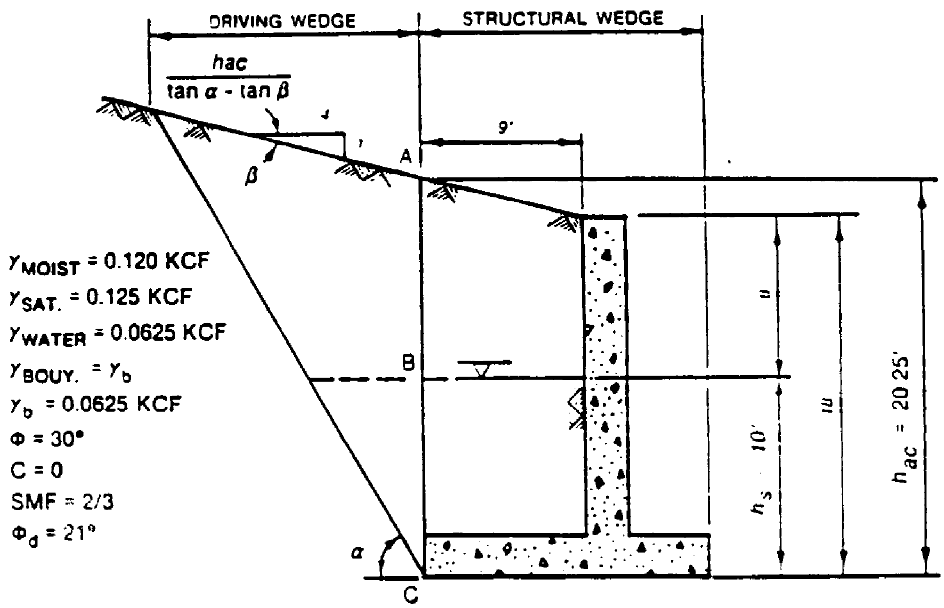
1. The following examples demonstrate the method of computing earth pressures using the simplified pressure coefficient method described in paragraph 5c of this ETL.

2. Examples 1 through 3 of this enclosure are taken from EM 1110-2-2502. The results of the examples are compared against the results obtained using the simplified pressure coefficient method. Example 4 demonstrates additional geometry configurations.

EXAMPLE 1

3. This example is taken from EM 1110-2-2502, Example 3, page M-7. The lateral earth pressures will be computed by the simplified pressure coefficient method and compared to the results from EM 1110-2-2502.

4. The soil geometry and properties are shown in the figure below.



The following values were determined for the problem from EM 1110-2-2502.

$\alpha_{critical}$ = 45.466°

K = 0.44767

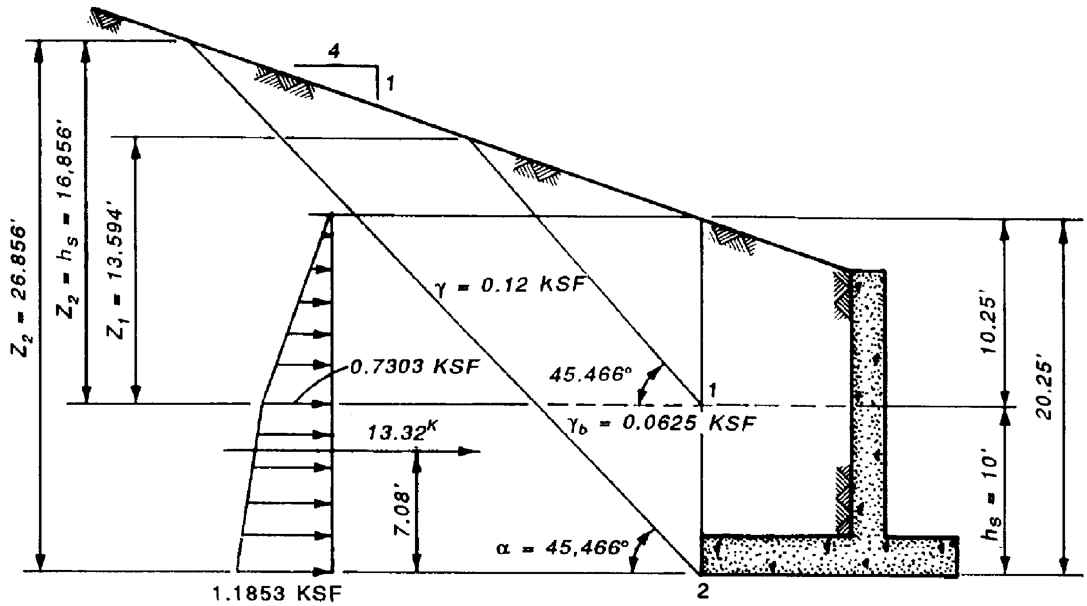
5. The pressures are calculated as follows for the points shown in the figure on the following page

$p_{v1} = \gamma z_1 = 0.12(13.594) = 1.6313$ ksf

$p_{v2} = \gamma(z_2 - h_s) + \gamma_b h_s = 0.12(16.856) + 0.0625(10) = 2.6477$ ksf

$p_{h1} = Kp_{v1} = 0.44767(1.6313) = 0.7303$ ksf

$p_{h2} = Kp_{v2} = 0.44767(2.6477) = 1.1853$ ksf

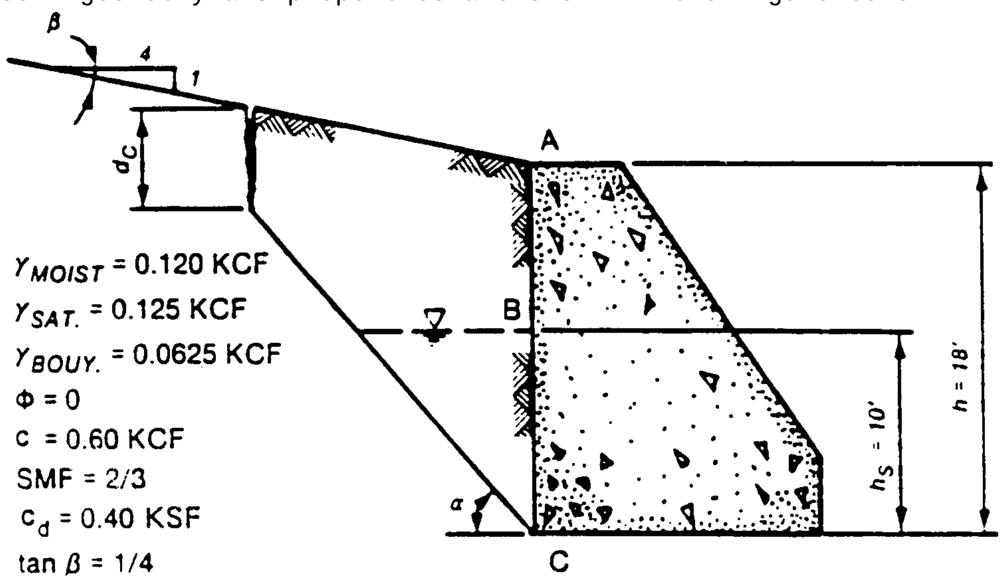


The solution agrees with the solution found in EM 1110-2-2502.

EXAMPLE 2

6. This example is taken from EM 1110-2-2502, example 5, page M-21. The lateral earth pressures will be computed by the simplified pressure coefficient method and compared to the results from EM 1110-2-2502.

7. The soil geometry and properties are shown in the figure below.



The following values were determined for the problem from EM 1110-2-2502

$\alpha_{critical} = 29°$

$d_c = 7.86$ ft

$K = 1.00$

Using the equation for K_c in Appendix H from EM 1110-2-2502 yields

$$K_c = \frac{1}{2 \sin \alpha \cos \alpha} \cdot \frac{\tan \alpha}{\tan \alpha - \tan \beta} = 2.14791$$

8. The pressures for the points shown in the figure below are calculated as follows:

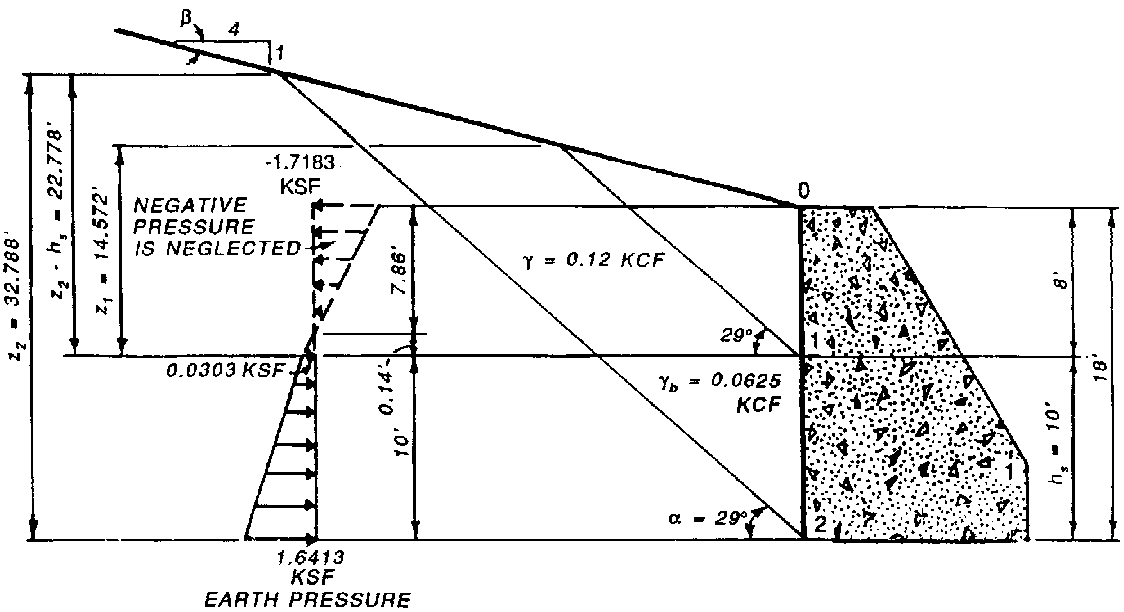
$p_{v1} = \gamma z_1 = 0.12(14.572) = 1.7486$ ksf

$p_{v2} = \gamma(z_2 - h_s) + \gamma_b h_s = 0.12(22.788) + 0.0625(10) = 3.3596$ ksf

$p_{ho} = -2K_c c_d = -2(2.1479)(0.4) = -1.7183$ ksf

$p_{h1} = Kp_{v1} - 2K_c c_d = 1.0(1.7486) - 1.7183 = 0.0303$ ksf

$p_{h2} = Kp_{v2} - 2K_c c_d = 3.33596 - 1.7183 = 1.6413$ ksf

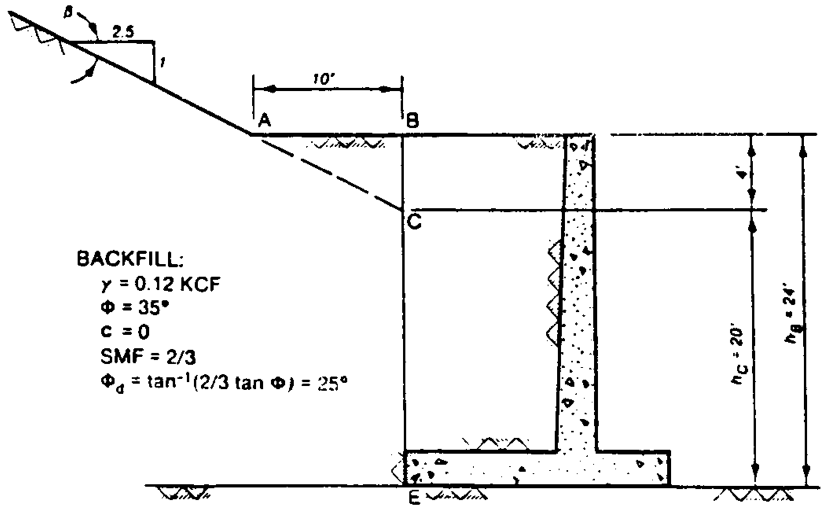


The negative pressures down to depth d_c are neglected. The positive pressures agree with the EM 1110-2-2502 solution.

EXAMPLE 3

9. This example is taken from EM 1110-2-2502, example 9, page M-52. The lateral earth pressures will be computed by the simplified pressure coefficient method and compared to the results from EM 1110-2-2502.

10. The soil geometry and properties are shown in the figure below.



The following values were calculated in EM 1110-2-2502

$\alpha_{critical} = 44.302°$

$K = 0.3589$

11. The pressures for the points shown on the figure on the following page are calculated as follows:

$p_{v1} = \gamma z_1 = 0.12(4.0) = 0.4800$ ksf

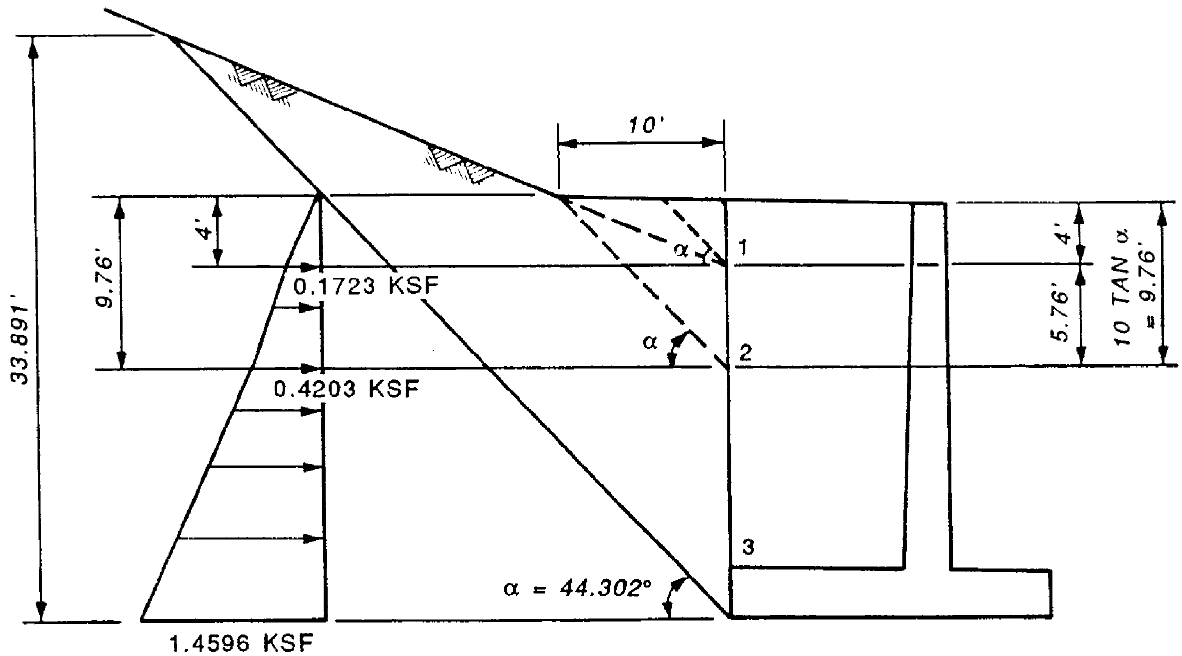
$p_{v2} = \gamma z_2 = 0.12(9.76) = 1.1712$ ksf

$p_{v3} = \gamma z_3 = 0.12(33.891) = 4.0669$ ksf

$p_{h1} = Kp_{v1} = 0.3589(0.4800) = 0.1723$ ksf

$p_{h2} = Kp_{v2} = 0.3589(1.1712) = 0.4203$ ksf

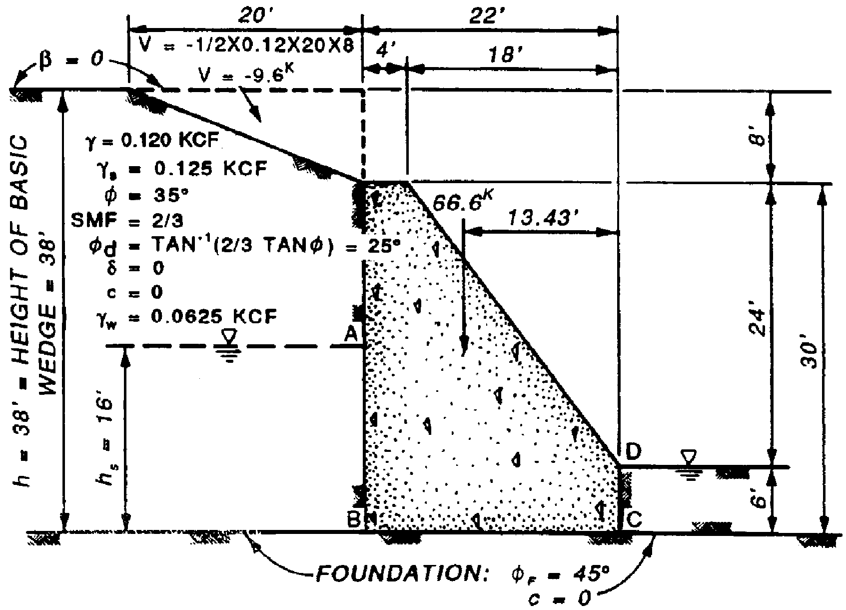
$p_{h3} = Kp_{v3} = 0.3589(4.0669) = 1.4596$ ksf



The pressures calculated agree with the solution found in EM 1110-2-2502.

EXAMPLE 4

12. The lateral earth pressures for the driving side will be computed by the simplified pressure coefficient method for the problem shown in the figure below.



13. The water pressures are calculated using the line of creep method.

Differential head = 16 ft - 6 ft = 10 ft

L_s = Total length of the seepage path = $L_{AB} + L_{BC} + L_{CD}$

= 16 + 22 + 6 = 44 ft

$$\text{Seepage gradient } i = \frac{10 \text{ ft}}{44 \text{ ft}} = 0.2273$$

$u_b = [16 - 0.2273(16)]0.0625 = 0.773$ ksf

$u_c = [16 - 0.2273(16 + 22)]0.0625 = 0.460$ ksf

14. The buoyant unit weights of the soil may now be calculated.

For the left side:

Effective unit weight of water $\gamma_{we} = \gamma_w(1 - i) = 0.0483$ kcf

$\gamma_{bL} = \gamma_s - \gamma_{we} = 0.125 - 0.0483 = 0.0767$ kcf

For the right side:

Effective unit weight of water $\gamma_{we} = \gamma_w(1 + i) = 0.07671$ kcf

$\gamma_{bR} = \gamma_s - \gamma_{we} = 0.125 - 0.0767 = 0.0483$ kcf

15. The critical slip plane angle α and K may now be calculated. To calculate the critical slip plane angle, the average unit weight of the soil in the wedge must be used. This is calculated as

$$\gamma_{avg} = \frac{\gamma h^2 - (\gamma - \gamma_{bL})h_s^2}{h^2}$$

$$= \frac{0.12(38)^2 - (0.12 - 0.0767)(16)^2}{38^2} = 0.1123 \text{ kcf}$$

Also the soil wedge EFG is modeled as a negative surcharge equal to

$$V = -\frac{1}{2}(0.12)(20)(8) = -9.6 \text{ kips}$$

The average unit weight is now used in Equation 3-30 from EM 1110-2-2502

$$A = \tan \phi_d - \frac{2V(1 + \tan^2 \phi_d)}{\gamma h^2}$$

$$= \tan 25° - \frac{2(-9.6)(1 + \tan^2 25°)}{0.1123(38)^2}$$

$$= 0.610454$$

From Equations 3-28 and 3-29 from EM 1110-2-2502

$$c_1 = \frac{2 \tan^2 \phi_d}{A}$$

$$= \frac{2 \tan^2 25°}{0.610454}$$

$$= 0.712398$$

$$c_2 = \frac{\tan \phi_d}{A}$$

$$= \frac{\tan 25°}{0.610454}$$

$$= 0.763871$$

The critical slip plane angle α may now be calculated from Equation 3-25 from EM 1110-2-2502.

$$\alpha_{critical} = \tan^{-1}\left(\frac{c_1 + \sqrt{c_1 + 4c_2}}{2}\right) = 52.4313°$$

The basic pressure coefficient K may now be calculated using the following equation from Appendix H of EM 1110-2-2502.

$$K = \frac{1 - \tan \phi_d \cot \alpha}{1 + \tan \phi_d \tan \alpha}$$

$$= \frac{1 - \tan 25° \cot 52.4313°}{1 + \tan 25° \tan 52.4313°}$$

$$= 0.39927$$

16. The earth pressures may now be calculated for the points shown in the figure on the following page.

$p_{v1} = 0.12(20.222) = 2.4266$ ksf

$p_{v2} = 0.12(22) + 0.0767(4) = 2.9468$ ksf

$p_{v3} = 0.12(22) + 0.0767(16) = 3.8672$ ksf

$p_{h1} = Kp_{v1} = 0.33927(2.4266) = 0.9689$ ksf

$p_{h2} = Kp_{v2} = 0.33927(2.9468) = 1.1766$ ksf

$p_{h3} = Kp_{v3} = 0.33927(3.8672) = 1.5441$ ksf